Internal financial constraints, external financial constraints, and investment choice: Evidence from a panel of UK firms

by

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Abstract

This paper uses a panel of 24184 UK firms over the period 1993-2003 to study the extent to which the sensitivity of investment to cash flow differs at firms facing different degrees of internal and external financial constraints. Our results suggest that when the sample is split on the basis of the level of internal funds available to the firms, the relationship between investment and cash flow is U-shaped. On the other hand, the sensitivity of investment to cash flow tends to increase monotonically with the degree of external financial constraints faced by firms. Combining the internal with the external financial constraints, we find that the dependence of investment on cash flow is strongest for those externally financially constrained firms that have a relatively high level of internal funds.

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1. Introduction

An intense debate has been taking place in recent years about the extent to which firms' investment is constrained by the availability of finance, and more specifically, about whether a positive and statistically significant relationship between investment and cash flow can be seen as an indicator of financial constraints (see Schiantarelli, 1995; Hubbard, 1998; and Bond and Van Reenen, 2005, for surveys).

The debate has been almost entirely based on data from firms quoted on the stock market. Yet, financial constraints on quoted firms are likely to be relatively weak, as these firms are typically large, long-established, financially healthy companies with good credit ratings. A sharper test of the effects of financial constraints on investment would be obtained from a sample that included a large number of unquoted firms, which are more likely to be characterized by adverse financial attributes such as poor solvency, a short track record, and low real assets compared to quoted firms.

Accordingly, in the present study, we attempt to shed further light on the debate by using, for the first time, a large panel of financial data on UK firms, over 99 percent of which are not quoted on the stock market. Specifically, we estimate, both separately and jointly, the effects of "internal" financial constraints (availability of internal funds) and "external" financial constraints (access to external finance) on firms' investment. Using firms' cash flow and coverage ratio as measures of the former, and firms' size and age as proxies for the latter, we find that the sensitivity of investment to cash flow responds differently according to the type of constraint. The sensitivity is particularly large when external constraints are strong and internal constraints are weak. This suggests that investment by successful young, small firms may be significantly constrained by access to external finance, which has long been a matter of policy concern.

The remainder of the paper is laid out as follows. In Section 2, we provide an economic background for our analysis. Section 3 contains a description of our data set, together with some summary statistics. Section 4 illustrates our baseline specification and our estimation methodology. Section 5 presents our main results and robustness tests, and Section 6 concludes.

2. Economic background

The debate on whether high sensitivities of investment to cash flow can be interpreted as indicators of financial constraints started with Fazzari, Hubbard, and Petersen's (FHP hereafter) 1988 pioneering paper, according to which firms with low dividend payout ratios (i.e. firms that are more likely to face financial constraints) display a high sensitivity of investment to cash flow. A number of papers followed, focusing not only on firms' investment behavior, but also on their inventory investment (Carpenter et al., 1994, 1998; Kashyap et al., 1994; Guariglia, 1999, 2000; Benito, 2005), their R&D investment (Bond et al., 1999; Carpenter and Petersen, 2002b), their employment decisions (Nickell and Nicolitsas, 1999; Sharpe, 1994); and more in general their growth (Carpenter and Petersen, 2002a). These studies generally supported FHP's (1988) main conclusion.

A significant challenge to FHP's (1988) work came with Kaplan and Zingales (hereafter KZ, 1997). Instead of using the dividend payout ratio as an indicator of financial constraints, these authors used other criteria, reclassifying FHP's low-dividend sub-sample of firms on the basis of information contained in the firms' annual reports as well as managements' statements on liquidity. They found that investment at firms that appeared *less* financially constrained by these criteria was *more*, rather than less, sensitive to cash flow than investment at other firms. They therefore concluded that higher sensitivities of investment to cash flow cannot be interpreted as evidence that firms are more financially constrained. A heated debate followed (Cleary, 1999; FHP, 2000; KZ, 2000; Allayannis and Mozumdar, 2004; Cleary et al., 2007).

The different conclusions reached by these two groups of authors can be explained by the different ways in which they measured financial constraints. On the one hand, most studies that have found results in line with those of FHP (1988) defined financial constraints using criteria such as firms' size, age, dividend payout ratio, or information on whether they have a bond rating and/or access to commercial paper. These criteria can be seen as proxies of the extent to which firms are susceptible to the effects of information asymmetries, which translate themselves in difficulties in obtaining external funds (i.e. as proxies for the degree of external financial constraints faced by the firms). Smaller and younger firms are particularly susceptible to information asymmetry effects, since little public information is available for them, and it is more difficult for financial institutions to gather this information. Obtaining external finance is therefore likely to be particularly costly for these firms (Bernanke et al., 1996). Similarly, when seeking for external finance, firms with a low dividend-payout ratio are also likely to be subject to moral hazard and adverse selection problems. In an asymmetric information setting, dividends are in fact used by firms to convey information to shareholders, and more in general, to the outside world. Firms that pay high dividends signal that they have good long-term prospects, while the opposite holds for low-dividend paying firms (Bhattacharya, 1979; John and Williams, 1985; Miller and Rock, 1985). Once again, obtaining external finance will be more difficult for the latter. Finally, variables such as access to the commercial paper market and bond rating are used because firms must reach a minimum size, collateral level, and age before the additional risk associated with information asymmetries is low enough to make bond issuance feasible or to obtain access to the commercial paper market (Calomiris et al., 1995).

On the other hand, the majority of studies that have found results in line with KZ (1997), classified firms or observations on the basis of indicators related to the level of internally generated funds available to them, which can be seen as a proxy for the degree of internal financial constraints that they face. In particular, KZ (1997) based their sample separation criteria essentially on variables related to firms' liquidity (which is obviously strongly correlated with the level of internal funds available to firms). Similarly, Cleary (1999) used a number of variables strongly related to firms' internal funds (e.g. the current ratio, the coverage ratio etc.) to construct an index of firms' financial strength[1].

These considerations strongly suggest that internal and external financial constraints have different effects on the investment-cash flow relationship. One of the contributions of this paper is to investigate this issue more in depth. It has to be noted, however, that the concepts of internal and external financial constraints may be related. A firm with greater internal cash flow may in fact find it easier to obtain external finance, as it will be perceived as less risky by lenders, considering that a high internal cash flow can be seen as evidence of the firm's managers' commitment

[1]Exceptions are Kadapakkam et al. (1998) and Cleary (2006) who estimated investment equations for a number of developed countries, and found that the sensitivities of investment to cash flow are often higher for larger firms and firms with higher dividend payout ratios. Yet, as discussed in Islam and Mozumdar (2002), their results are likely to be driven by insufficient cross-sectional heterogeneity in within-country samples.

to their investment projects (Leland and Pyle, 1977). Conversely, firms that are internally financially constrained will find it more difficult to obtain external finance.

The work of Cleary et al. (2007) is most clearly related to ours in that it also attempts to distinguish (both theoretically and empirically) between the effects of internal and external financial constraints on the sensitivity of investment to cash flow. Specifically, Cleary et al. (2007) construct a model showing that this sensitivity is determined by the interactions between a cost and a revenue effect. On the one hand, the cost effect arises because, assuming that internal funds are high but insufficient to finance all of the firm's investment requirements, higher levels of investment are typically associated with higher borrowing, higher repayment costs, and, consequently, a higher risk of default. This effect suggests a positive relationship between cash flow and investment: a drop in cash flow leads to a drop in investment, as this strategy allows the firm to avoid the higher borrowing, higher repayment costs, and resulting higher risk of default that would follow from keeping investment constant or from increasing it. On the other hand, a revenue effect arises because a higher level of investment generates higher revenue, which lowers the firm's risk of default. This effect suggests a negative relationship between cash flow and investment. In this case, a drop in cash flow leads to higher investment, as this strategy improves the firm's ability to repay its debt, avoiding bankruptcy, and increases the lender's payoff in case of default.

Because both cost and revenue effects operate in the economy, and because the two effects lead to different predictions about the sensitivity of investment to cash flow, the exact relationship between these two variables depends on which of the two effects prevails. If the cost effect dominates, then one should observe a positive link between investment and cash flow, whereas if the revenue effect dominates, a negative link should be observed. According to Cleary et al. (2007), the latter scenario takes place for firms characterized by negative (or particularly low) internal funds. For these firms, a large share of any loan would have to be used to pay existing debts or cover fixed costs, i.e. to try and make cash flow positive. Therefore, in the presence of a falling cash flow, these firms would have to increase their investment, in order to generate sufficient revenue to achieve this goal.

The model's predictions are therefore as follows. If firms are classified on the basis of their internal funds (i.e. on the basis of their cash flow, or more in general, of the degree of internal financial constraints that they face), then the relationship between investment and cash flow should be U-shaped, with firms characterized by negative (or particularly low) cash flow displaying negative investment-cash flow sensitivities. If on the other hand, firms are classified on the basis of indicators of the capital market imperfections that they face, such as size, age, or bond rating (i.e. indicators of asymmetric information, or more in general, of the degree of external financial constraints that they face), then the relationship between investment and cash flow could be positive or negative depending on whether the cost or the revenue effect dominates. The former effect is more likely to dominate if the negative cash flow observations are few or totally absent from the sample. The model also predicts that when the relationship between investment and cash flow is positive, increased informational asymmetry strengthens the investment-cash flow sensitivity. Cleary et al. (2007) test their model using data for US quoted firms drawn from Compustat and find strong empirical support for it.

Our work differs from Cleary et al. (2007)'s in four important ways. First, and most importantly, while their sample is confined to quoted firms (in the United States), which are unlikely to display a wide enough range of financial constraints, ours mainly includes unquoted firms. This is important considering that Cleary et al. (2007) themselves state that "it is difficult to find good proxies for capital market imperfections that vary enough across observations in the sample (especially with Compustat data, where all firms are publicly traded)." (p. 31).

Second, our paper is based on a sample from the United Kingdom. The relative lack of corporate bond and commercial paper markets, the relative thin and highly regulated banking and equity markets, and the relatively small amount of venture capital financing, seem to make the idea of financial constraints that affect firm behavior more plausible in a European context than in the US.

Third, we provide a richer analysis of the effects of internal and external constraints: our analysis provides estimates not only of the individual effects that internal and external financial constraints have on the sensitivities of firms' investment to cash flow, but also of the effects of various combinations of these two types of constraints, trying to identify those combinations leading to higher sensitivities.

Finally, instead of using a *Q* model framework to estimate our investment regressions, we use error-correction specifications[2]. The main advantage of using an error-correction model (ECM) is that it leads to a more flexible specification than the *Q* approach, which is consequently less likely to suffer from mis-specification problems. In particular, contrary to the *Q* model, the ECM specification maintains the long-run properties of value-maximising investment models, but does not impose the restrictions on short-run dynamics associated with particular adjustment cost specifications. Moreover, using the ECM specification allows us to by-pass to a certain extent the criticism according to which cash flow might be an important determinant of investment, simply because it accounts for investment opportunities, which are poorly measured by Tobin's *Q* (Cummins et al., 2006).

3. Main features of the data and summary statistics

3.1 The data set

We construct our data set from the profit and loss and balance sheet data gathered by Bureau Van Dijk Electronic Publishing in the *Financial Analysis Made Easy* (FAME) database. This provides information on companies for the period 1993-2003. Over 99 percent of the firms in the data set are not traded on the stock market. The firms in our data set operate in a wide range of industrial sectors, namely agriculture, forestry and mining; manufacturing; construction; retail and wholesale; hotels and restaurants; and business and other services[3]. Having access to firms operating in sectors other than manufacturing is beneficial for us, considering that the majority of studies that looked at the effects of financial constraints on firms' activities have focused essentially on the manufacturing sector. Yet, as explained in Bernanke et al. (1996), the share of sales by "small" firms is generally greater in other sectors.

We measure investment (*I*) as the purchase of fixed tangible assets by the firm. Cash flow (*CF*) is obtained as the sum of the firm's after-tax profits and depreciation. Our measure of the replacement value of capital stock (*K*) is calculated using the standard perpetual inventory formula (Blundell et al., 1992). In particular, we use tangible fixed assets as the historic value of the capital stock. We assume that replacement cost and historic cost are the same in the first year of data for each firm.

[2] Given that our panel includes mainly unquoted firms, it would be impossible to estimate a *Q* model, as Tobin's *Q*, which is defined as the market value of the firm over the replacement value of its capital stock, cannot be calculated for unquoted firms.

We then apply the perpetual inventory formula as follows: $K_{t+1} = K_t *(1-\delta)*(p_{t+1} /p_t)+ I_t$, where t indexes time; δ represents the depreciation rate, which we assume to be constant and equal to 5.5 percent for all firms; and p_t is the price of investment goods, which we proxy with the implicit deflator for gross fixed capital formation.

We exclude companies that changed the date of their accounting year-end by more than a few weeks, so that the data refer to 12 month accounting periods. Firms that do not have complete records on investment, cash flow, or sales are also dropped, as well as firms with less than 3 years of continuous observations. Finally, to control for the potential influence of outliers, we exclude observations in the 1 percent tails for each of the regression variables. These cut-offs are aimed at eliminating observations reflecting particularly large mergers, extraordinary firm shocks, or coding errors. These types of rules are common in the literature and we employ them to ensure comparability with previous work (Bond et al., 2003; Cummins et al., 2006).

The data sets that we use in estimation include a total of 39270 annual observations on 7534 companies, when we only focus on the manufacturing sector; and 124590 annual observations on 24184 companies, when we focus on our broader range of industries. Both samples cover the years 1996-2003 and have an unbalanced structure, with the number of years of observations on each firm varying between 3 and 8[4]. By allowing for both entry and exit, the use of an unbalanced panel partially mitigates potential selection and survivor bias.

3.2 Sample separation criteria

We use the level of the cash flow to beginning-of-period capital stock ratio available to firms as a proxy for the degree of internal financial constraints that they face, and the firms' size as a proxy for the degree of external financial constraints that they face. It is sensible to use cash flow as a proxy for internal funds for two main reasons. First, cash flow can take negative values. This is particularly important as according to Cleary et al.'s (2007) model, it is for those firms whose internal funds are sufficiently negative, that a negative relationship between investment and internal

[3] Following Cleary et al. (2007), we exclude firms operating in regulated or financial sectors.

[4] See Appendix 1 in Guariglia (2007) for more information on the structure of our panel and more complete definitions of all variables used. Also note that because our model includes variables lagged up to two times and is estimated in first-differences, the first three cross-sections of the data cannot be used in estimation: for this reason, although our original data set covers the period 1993-2003, the data set actually used in estimation only covers the years 1996-2003.

funds is more likely to be observed. Second, cash flow has been widely used in the investment literature as a measure of internal funds (see Schiantarelli, 1995; Hubbard et al., 1998, and Bond and Van Reenen, 2005). Yet, cash flow is not a perfect measure of internal funds because it is a flow variable, which does not include the stock of funds accumulated in the past. One can, however, claim that since cash flow is the main source of variation in internal funds, firms with negative cash flow are likely to have a low or negative level of internal funds (Cleary et al., 2007).

We first test whether cash flow has a differential impact on the investment of firms with different degrees of internal financial constraints. For this purpose, as in Cleary et al. (2007), we initially split firms on the basis of their cash flow to beginning-of-period capital stock ratio. We therefore construct the following dummy variables:

i. $NEGCF_{it}$, which is equal to 1 if firm i has a negative cash flow to capital ratio at time t, and equal to 0, otherwise;

ii. $MEDCF_{it}$, which is equal to 1 if firm i has a positive cash flow to capital ratio in year t, which falls below the 75th percentile of the distribution of the corresponding ratios of all the firms operating in the same industry as firm i in that particular year, and equal to 0, otherwise;

iii. $HIGHCF_{it}$, which is equal to 1 if firm i displays a positive cash flow to capital ratio in year t, which falls above the 75th percentile of the distribution of the corresponding ratios of all the firms operating in the same industry as firm i in that particular year, and equal to 0, otherwise.

We use these dummies in our investment regressions as interactions on the cash flow term. In this way, we allow firms to transit between classes[5].

To check robustness, we also use firms' financial status dummies defined in a similar way as above, but based on their coverage ratio ($NEGCOV_{it}$; $MEDCOV_{it}$, $HIGHCOV_{it}$). The coverage ratio is defined as the ratio between firms' total profits before tax and before interest and their total interest payments, and indicates the availability of internal funds that firms can use to finance their real activities. As the coverage ratio has been widely used in the literature on the effects of financial constraints on firms' activities (see Carpenter et al., 1998; Guariglia, 1999, 2000; and

[5] For this reason, our empirical analysis will focus on firm-years rather than simply firms. See Kaplan and Zingales (1997) and Guariglia (2000) for a similar approach. The equations that we estimate are described in detail in Section 4.1.

Whited, 1992), we use this variable as our second measure of firms' internal funds, instead of the net liquidity to capital ratio, which was used by Cleary et al. (2007).

We then investigate whether cash flow has a different impact on the investment of firms facing different degrees of external financial constraints. For this purpose, we first partition firms on the basis of their size, measured by their total real assets. Smaller firms are likely to face more severe problems of asymmetric information as they are more likely to suffer from idiosyncratic risk, and to have lower collateral values in relation to their liabilities, as well as higher bankruptcy costs, and short track records (Schiantarelli, 1995). Each year, we consider a firm's size in comparison with the situation of other firms in the industry in which that firm operates. We define as small firm-years ($SMALL_{it}$=1) within an industry, those firms whose real assets in year *t* are in the lowest quartiles of the distribution of the assets of all the firms in that particular industry and year. Similarly, we define as medium-sized firm-years ($MEDIUM_{it}$=1) within an industry, those firms whose real assets in year *t* fall in the second and third quartiles of the distribution. Finally, large firm-years ($LARGE_{it}$=1) are those firm-years with assets in the highest quartile of the distribution.

To check robustness, we also define the degree of asymmetric information faced by our firms in capital markets on the basis of their age, which is defined as the time elapsed since the incorporation date of the company. Younger firms are more likely to face problems of asymmetric information, as their short track record makes it more difficult to judge their quality. We consider as young firm-years ($YOUNG_{it}$=1) within an industry, those firms whose age in year *t* falls in the lowest quartiles of the distribution of the ages of all the firms in that particular industry and year. Similarly, we define as middle-aged firm-years ($MIDDLEAGED_{it}$=1) within an industry, those firms whose age in year *t* is in the second and third quartiles of the distribution. Finally, old firm-years (OLD_{it}=1) are those with age in the highest quartile of the distribution[6].

[6] All our results were generally robust to using different cut-off points both for the internal and the external financing constraints. Note that all our dummy variables were defined on the full sample, which is not the sample actually used in estimation for the reasons documented in footnote 4.

3.3 Summary statistics

Table 1 presents the means and standard deviations of the variables used in our regressions. Panel A refers to the manufacturing sector only, whereas Panel B refers to our broader sample including a wide range of other industrial sectors. In both panels of the Table, column (1) refers to the full sample, columns (2) to (4), to the sub-samples based on the cash flow to capital ratio, and columns (5) to (7), to the sub-samples based on firms' size[7].

We can see from both panels of the Table, that when firm-years (indexed by *it*) are classified on the basis of their cash flow to capital ratio ($CF_{it}/K_{i(t-1)}$), sales growth (Δs_{it}) tends to rise monotonically as we move from firm-years with negative cash flow to firm-years with high cash flow. The same happens to the investment to capital ratio ($I_{it}/K_{i(t-1)}$) when we focus on the manufacturing sector (Panel A). Furthermore, both for the manufacturing sector and our broader sample, assets tend to be highest for those firm-years in the middle category. When firm-years are divided on the basis of their assets, it is the smallest firm-years which tend to have the highest investment to capital ratios, as well as the highest cash flow to capital ratios.

Table 2 illustrates the behavior of investment to capital ratios for different percentiles of the cash flow to capital ratio. Columns (1) and (2) refer to the manufacturing sector and columns (3) and (4), to our broader sample. In both cases, we can see that the investment-cash flow relationship is U-shaped: the investment to capital ratios reach a minimum when the cash flow to capital ratio is around 0, and then increase both when cash flow becomes negative, and when it rises above 0.

It is noteworthy that the percentage of firm-years with negative cash flow is 12.9 percent in our manufacturing sector sample, and 12.7 percent in our broader sample. For small firm-years, the corresponding percentages are 14.5 percent in the manufacturing sector, and 13.5 percent in our broader sample. For medium-sized firm-years, they are 12.7 percent in the manufacturing sector, and 12.8 percent in our broader sample; and for large firm-years 12.6 percent in the manufacturing sector, and 12.4 percent in our broader sample. It appears therefore that the splits of firm-years on the basis of the cash flow to capital ratio and real assets are not strongly correlated, as a similar percentage of firms with negative cash flow can be found among the small, medium, and large firm-years, and as real assets do not grow monotonically with cash flow. Dividing firm-years on the basis of their cash flow to capital ratio and on the basis of their assets, will therefore not necessarily lead to equal patterns of the investment-cash flow sensitivities for financially constrained and unconstrained firm-years. In the section that follows, we will provide formal tests of how the sensitivities change with the degree of internal and external financial constraints faced by firms.

4. Baseline specification and estimation methodology

4.1 Baseline specification

We initially estimate the following error-correction specification (see Bond et al., 2003; Bond and Lombardi, 2006; and Bloom et al., 2007, for a similar specification):

$$I_{it}/K_{i(t-1)} = a_0 + a_1 I_{i(t-1)}/K_{i(t-2)} + a_2\Delta s_{it} + a_3\Delta s_{i(t-1)} + a_4(k_{i(t-2)}-s_{i(t-2)}) + \\ + a_5\, CF_{it}/K_{i(t-1)} + v_i + v_t + v_{jt} + e_{it} \tag{1}$$

where I is the firm's investment; K, the replacement value of its capital stock, and k, its logarithm; s, the logarithm of real sales; and CF, the firm's cash flow. The subscript i indexes firms; j, industries; and t, time, where t=1996-2003[8].

Error-correction behavior enters the empirical framework because of adjustment costs. In their presence the firm will not immediately adjust its capital stock (k) to the target level (s), which is assumed to be a function of sales. We specify a dynamic adjustment mechanism between k and s (the details of which are contained in Appendix 3 in Guariglia, 2007). To be consistent with error-correction behavior, the coefficient associated with the term ($k_{i(t-2)}$-$s_{i(t-2)}$) should be negative: if capital is lower (higher) than its desired level, future investment should be higher (lower).

The error term in Equation (1) is made up of four components: v_i, which is a firm-specific component; v_t, a time-specific component accounting for possible business cycle effects; v_{jt}, a time-specific component which varies across industries, accounting for industry-specific shifts in investment demand or expectations

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[7] Summary statistics for the sub-samples based on the coverage ratio and on firms' age are reported in Table A1 in Appendix 2 in Guariglia (2007).

[8] In our manufacturing sample, firms are allocated to one of the following sectors: metals and metal goods; other minerals, and mineral products; chemicals and man made fibres; mechanical engineering; electrical and instrument engineering; motor vehicles and parts, other transport equipment; food, drink, and tobacco; textiles, clothing, leather, and footwear; and others (Blundell et al., 1992). In our broader sample, firms are allocated to the following groups: agriculture, forestry, and mining; manufacturing;

(Carpenter and Petersen, 2002a); and e_{it}, an idiosyncratic component. We control for v_i by estimating our equations in first-differences, for v_t by including time dummies, and for v_{jt} by including industry dummies interacted with time dummies in all our specifications.

When focusing on the differential impact of cash flow on the investment of different categories of firms, instead of estimating our investment equations on separate sub-samples of firms as in Cleary et al. (2007), we interact the cash flow variable in all our specifications with dummy variables indicating the degree of internal and external financial constraints faced by the firm. This approach allows us to avoid problems of endogenous sample selection; to gain degrees of freedom; and to take into consideration the fact that firms can transit between groups. We estimate equations of the type:

$$I_{it} /K_{i(t-1)} = a_0 + a_1 I_{i(t-1)}/K_{i(t-2)} + a_2 \Delta s_{it} + a_3 \Delta s_{i(t-1)} + a_4(k_{i(t-2)}-s_{i(t-2)}) + \\ +a_{51} [CF_{it} /K_{i(t-1)}*CATEGORY1_{it}] + a_{52} [CF_{it} /K_{i(t-1)}*CATEGORY2_{it}] + \\ a_{53} [CF_{it} /K_{i(t-1)}*CATEGORY3_{it}] + v_i + v_t + v_{jt} + e_{it}, \quad (2)$$

where $CATEGORY1_{it}$, $CATEGORY2_{it}$, and $CATEGORY3_{it}$ refer in turn to the dummy variables based on the firms' cash flow to capital ratio ($NEGCF_{it}$, $MEDCF_{it}$, $HIGHCF_{it}$); to those based on their coverage ratio ($NEGCOV_{it}$, $MEDCOV_{it}$; $HIGHCOV_{it}$); on their size ($SMALL_{it}$, $MEDIUM_{it}$; $LARGE_{it}$); and on their age ($YOUNG_{it}$, $MIDDLEAGED_{it}$, OLD_{it}).

4.2 Estimation methodology

We estimate Equations (1) and (2) using the first-difference Generalized Method of Moments (GMM) estimator developed by Arellano and Bond (1991). This technique takes unobserved firm heterogeneity into account by estimating the equation in first-differences, and controls for possible endogeneity problems by using the model variables lagged two or more periods as instruments[9].

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construction; retail and wholesale; hotels and restaurants; business services; others (which include education, health, social work, repairs entertaining, and renting).

[9] Our results were generally robust to using OLS, the within-groups estimator, and the system-GMM estimator developed in Blundell and Bond (1998), as well as to interacting all the regressors with the *CATEGORY* dummies, and to including two of the *CATEGORY* dummies in addition to the interaction terms. These estimates are not reported for brevity, but are available from the authors upon request.

In order to evaluate whether our model is correctly specified, we use two criteria: the Sargan test (also known as *J* test) and the test for second-order serial correlation of the residuals in the differenced equation (*m2*). If the model is correctly specified, the variables in the instrument set should be uncorrelated with the error term in Equations (1) and (2). The *J* statistic tests overidentifying restrictions. Under the null of instrument validity, it is asymptotically distributed as a chi-square with degrees of freedom equal to the number of instruments less the number of parameters. The *m2* test is asymptotically distributed as a standard normal under the null of no second-order serial correlation of the differenced residuals, and provides a further check on the specification of the model and on the legitimacy of variables dated t-2 as instruments in the differenced equation[10].

5. Empirical results

5.1 Investment equations without interactions

Table 3 presents the estimates of Equation (1). Column (1) refers to the full manufacturing sector sample. As expected the error-correction term attracts a negative sign, and the sales growth terms are both positive and statistically significant. The positive and precisely determined coefficient associated with the cash flow to capital ratio suggests that the cost effect prevails over the revenue effect: a drop in cash flow is associated with a drop in investment, possibly to avoid the higher borrowing, higher repayment costs, and resulting higher risk of default that would follow if investment were to be kept unchanged or increased. The point estimate (0.055) indicates that the elasticity of investment with respect to cash flow, evaluated at sample means, is 0.121. A 10 percent increase in cash flow leads therefore to a 1.21 percent increase in investment. Neither the Sargan test, nor the *m2* test for second-order autocorrelation of the differenced residuals indicate problems with the specification of the model or the choice of the instruments.

Column (2) reports the full sample estimates, for our broader sample. Once again, the coefficient associated with cash flow (0.038) is positive and precisely determined. Compared to the manufacturing sector, however, cash flow has a weaker effect on firms' investment: the elasticity of investment with respect to cash flow is

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[10] If the undifferenced error terms are *i.i.d.*, then the differenced residuals should display first-order, but not second-order serial correlation. Note that neither the *J* test nor the *m2* test allow us to discriminate between bad instruments and model specification.

now 0.107, compared to 0.121 for the manufacturing sector. This might be explained by the fact that agency costs are more substantive for manufacturing firms, as their assets are "more specialized" and can less readily "serve as collateral" (Schaller, 1993).

In columns (3) and (4), we present the estimates of similar equations on samples, which exclude observations with negative cash flow to capital ratio. For the manufacturing sector (column 3), the coefficient associated with the cash flow variable is now 0.085, whereas the corresponding coefficient for our broader sample is 0.043 (column 4). Both coefficients are precisely determined, and larger than those reported in columns (1) and (2), although for our broader sample, the difference in the coefficients is rather small. This finding suggests that the observations with negative cash flow have lower (and possibly negative) investment-cash flow sensitivities than the other observations (see Allayannis and Mozumdar, 2004, for a similar finding).

Next, we will evaluate how exactly the investment-cash flow sensitivities differ across various sub-groups of firm-years.

5.2 Investment equations with interactions based on the degree of internal financial constraints faced by firms

Table 4 presents the estimates of Equation (2), where the interaction terms are based on the cash flow to capital ratio (columns 1 and 2, respectively for the manufacturing sector and our broader sample), and on the coverage ratio (columns 3 and 4, respectively for the manufacturing sector and our broader sample). Focusing on columns (1) and (2), we can see that the coefficient associated with cash flow is negative for firm-years with negative cash flow. Column (1) suggests that a 10 percent increase in cash flow is associated with a 4.23 percent drop in investment. The corresponding figure for column (2) is 1.69 percent. These figures indicate that for firms with negative cash flow, the revenue effect prevails over the cost effect. For these firms, a large share of any loan would have to be used to pay existing debts or cover fixed costs, i.e. to try and make cash flow positive. Therefore, in the presence of a falling cash flow, these firms would have to increase their investment, in order to generate sufficient revenue to achieve this goal.

Columns (1) and (2) also suggest that cash flow does not have a precisely determined effect on the investment of those firm-years characterized by a moderate level of cash flow to capital. On the other hand, it plays a positive and significant effect on the investment of firm-years with high cash flow, for which the cost effect is likely to prevail over the revenue effect. For these firm-years, focusing on the manufacturing sector, a 10 percent rise in cash flow is associated with a 2.89 percent rise in investment. The corresponding figure for our broader sample is 2.83 percent. These results are in line with the findings in Cleary et al. (2007), who find a U-shaped investment-cash flow relationship, and with those in KZ (1997), according to which the sensitivity of investment to cash flow is highest for the least financially constrained firms.

When the coverage ratio is used to differentiate the effects of cash flow on firms' investment, we obtain similar results as above for the manufacturing sector (column 3). Yet, when our broader sample is considered (column 4), cash flow attracts a positive and significant coefficient both for firm-years with middle-sized and high coverage ratio.

Table 4 also reports *p*-values associated with χ^2 tests aimed at assessing whether the impact of cash flow of investment is equal across various categories of firms-years. The results suggest that the hypothesis is always rejected when firm-years with negative cash flow/coverage ratio (which exhibit negative sensitivities) are compared with firm-years with high cash flow/coverage ratio (which exhibit positive sensitivities). The hypothesis is also rejected when firm-years with negative coverage ratio are compared with firm-years with medium-sized coverage ratio, and when manufacturing firm-years with medium-sized cash flow/coverage ratio are compared with manufacturing firm-years with high cash flow/coverage ratio.

5.3 Investment equations with interactions based on the degree of external financial constraints faced by firms

Table 5 presents the results of the estimates of Equation (2) when firm-years are differentiated into small, medium, and large (columns 1 and 2, respectively for the manufacturing sector and our broader sample) and into young, middle-aged, and old (columns 3 and 4, respectively for the manufacturing sector and our broader sample), i.e. on the basis of the degree of external financial constraints that they face.

In column (1), both small and medium-sized firm-years display a positive and precisely determined sensitivity of investment to cash flow, larger for the former (0.10) than for the latter (0.05). The elasticities evaluated at sample means suggest that a 10 percent rise in cash flow is associated with a 2.82 percent rise in investment for small firms, and a 1.10 percent rise for medium-sized firms. A similar pattern can be observed in column (2), where the coefficients are respectively 0.08 and 0.03 for small and medium-sized firm-years, indicating that a 10 percent rise in cash flow leads to a 2.52 percent rise in investment for small firms, and to a 0.84 percent rise for medium-sized firm-years. For large firm-years, the coefficient associated with cash flow is poorly determined in both columns. These findings show that the cost effect prevails for small and medium-sized firm-years, and that the former are more sensitive to asymmetric information issues than latter. For large firm-years, on the other hand, a drop in cash flow has no effect on investment, possibly because it is always possible for them to obtain financing through bank loans or the equity market.

When firm-years are split on the basis of their age (columns 3 and 4), the coefficients associated with cash flow are once again only significant for the youngest and middle-aged firm years, and generally larger for the former.

Table 5 also reports *p*-values associated with χ^2 tests aimed at assessing whether the impact of cash flow of investment is equal across various categories of firms-years. As expected, the results suggest that the hypothesis is always rejected when small/young firm-years are compared with large/old firm-years. It is rejected in three cases out of four when middle-sized/middle-aged firm-years are compared with large/old firm-years, and except in one case, cannot be rejected when small/young firm-years are compared with middle-sized/middle aged firm-years.

It appears therefore that, although also significant for middle-sized and middle-aged firm-years, the sensitivity of investment to cash flow is larger for the smallest and youngest firm-years, which are more prone to facing asymmetric information problems. The estimates in this Table are in line with the findings in FHP (1988), according to which firms more likely to face financial constraints exhibit higher sensitivities of investment to cash flow[11].

These findings have significant policy implications: the fact that smaller and younger firms exhibit a higher sensitivity of investment to cash flow suggests that in order to make the small business community thrive, policies aimed at making the

[11] The fact that in this Table the investment-cash flow sensitivities are never negative and precisely determined can be explained by considering that the percentage of firms with negative cash flow is relatively small in all sub-groups of firms.

access to finance easier for small and medium-sized enterprises (SMEs) are likely to be particularly effective.

Our results so far suggest that the different conclusions reached by FHP (1988) and KZ (1997) about whether higher sensitivities of investment to cash flow can be interpreted as evidence that firms are more financially constrained, are probably due to the to the different criteria used in their studies to partition their sample. We next analyze the sensitivities of investment to cash flow when the sample is split on the basis of combinations of various degrees of internal and external financial constraints.

5.5 Investment equations with interactions based on various combinations of internal and external financial constraints faced by firms

Columns (1) and (2) of Table 6 present the results of the estimation of Equation (1) when the effects of cash flow on investment are differentiated across firm-years facing various combinations of internal and external financial constraints, i.e. small, medium, and large firm-years with negative cash flow; small, medium, and large firm-years with medium cash flow; and small, medium, and large firm-years with high cash flow.

Column (1) reports the estimates for the manufacturing sector. It appears that cash flow attracts a positive and statistically significant effect only for those small and medium-sized firm-years with relatively high cash flow. The coefficient for the former (0.14) is higher than that for the latter (0.09), and higher than the corresponding coefficient on cash flow for small firm-years reported in column (1) of Table 5 (0.10). The elasticities evaluated at sample means suggest that a 10 percent rise in cash flow is associated with a 6.81 percent rise in investment for small firms with high cash flow, and with a 3.82 percent rise for medium-sized firms with high cash flow. These are sizeable effects. The *J* and *m2* tests do not indicate problems with the specification of the model and/or the instruments chosen.

Column (2) reports the estimates for our broader sample. Once again, it is the small firm-years with relatively high cash flow that display the highest sensitivity of investment to cash flow (0.07). For these firms a 10 percent increase in cash flow is associated with a 4.53 rise in investment. As in column (1), cash flow attracts a positive and significant coefficient also for the medium-sized firm-years with relatively high cash flow. This coefficient (0.04) is however smaller than that for small firm-years, and indicates that a 10 percent rise in cash flow is followed by a 2.51 percent rise in investment. Finally, in this specification, we can also observe a negative and significant coefficient for medium-sized firm-years with negative cash flow.

Columns (3) and (4) of Table 6 presents robustness tests in which cash flow and size are respectively replaced with the coverage ratio and age as sample separation criteria. Column (3) presents estimates for the manufacturing sector. Like in column (1), it is only those young and middle-aged firm-years with relatively high coverage ratio that display positive and significant sensitivities of investment to cash flow. The sensitivities amount to 0.16 and 0.09 respectively for the two types of firm-years. Column (4) refers to our broader sample. The results are similar to those reported in column (2).

We also perform tests aimed at assessing whether the impact of cash flow on investment is equal across various categories of firms-years. The results, which we do not report for brevity, suggest that the hypothesis is always rejected when medium-sized/middle aged firm-years with negative cash flow/coverage ratio (which exhibit negative sensitivities) are compared with small/young and middle-sized/middle-aged firms with high cash flow/coverage ratio (which show positive sensitivities). It is also rejected when the comparison is performed with large/old firm-years with high cash flow (which also display positive sensitivities). The hypothesis is rejected in the majority of cases when small/young and medium-sized/middle aged firm-years with high cash flow/coverage ratio are compared with large/old firm-years with high cash flow/coverage ratio, as the former typically exhibit positive sensitivities, while the latter show insignificant sensitivities.

The results in Table 6 can be interpreted as follows. External and internal financial constraints often have opposite effects on the sensitivities of investment to cash flow. For internally financially constrained firms, the revenue effect is likely to prevail, leading to a negative sensitivity of investment to cash flow. On the other hand, for those externally financially constrained firms, which are not internally constrained, the cost effect is likely to prevail, leading to a positive sensitivity. Thus, when the two types of constraints are combined, the sensitivities are the highest for those firm-years for which the cost effect dominates, i.e. for those which are unconstrained internally (having high cash flow and/or coverage ratios), and constrained externally (being small/medium-sized and/or young/middle-aged).

The fact that investment at firm-years which are constrained both internally and externally (being small/medium-sized or young/middle-aged and having a negative cash flow/coverage ratio) does not seem to be affected by cash flow can be explained by considering that a negative cash flow/coverage ratio leads to a negative sensitivity (given the prevalence of the revenue effect), whereas being small/medium-sized or young/middle-aged leads to a positive sensitivity (given the prevalence of the cost effect). These two contrasting effects might be offsetting each other, leading to a poorly determined coefficient for small/young and middle-sized/middle-aged firm-years with negative cash-flow/coverage ratios. For small/young firm-years with negative cash flow/coverage ratio, this result could also be explained by considering that these firm-years are particularly likely to be financially distressed. They might therefore have reached the minimum level of investment necessary to carry on production: further reductions in investment would therefore be impossible, even in response to declines in cash flow. Financially distressed firms might also be required by their creditors to use their cash flow to meet interest payments and/or improve the liquidity of their balance sheet (Fazzari et al., 2000; Allayannis and Monumbar, 2004; Cleary et al., 2007).

Investment at firm-years with medium-sized cash flow does not seem to be affected by changes in cash flow, whatever the degree of external financial constraints faced by the firms. As before, for small/medium-sized and young/middle-aged firm-years, this can be explained by considering that these firms might be experiencing both a cost effect, driven by the external dimension of their financial constraints (i.e. their small/medium size/age), and a revenue effect, driven by the internal dimension (i.e. the medium-sized cash flow/coverage ratio), whereby the two offset each other. Finally, large/old firm-years always exhibit insignificant sensitivities, probably because they do not suffer from financial constraints: even if they are internally constrained, they are always able to access external funds.

In the light of these results, in order to make an economy thrive in the short-run, public policies should endeavour to make access to finance easier especially for those SMEs characterized by relatively high levels of internal funds. It is in fact those SMEs that will convert this additional finance into additional investment. Funding low cash flow/coverage ratio SMEs could be beneficial in the medium-run, as these firms could initially use the additional funding for debt repayment rather than investment, which could provide a platform for greater future investment.

6. Conclusions

In this paper, we have used a panel of mainly unquoted UK firms, operating in a broad range of industrial sectors, to test whether internal and external financial constraints faced by firms have different effects on their sensitivity of investment to cash flow. Using data on unquoted firms has provided us with a unique opportunity to construct measures of financial constraints displaying a wide degree of variation across observations. Instead of using the traditional *Q*-model of investment in estimation, we have used an error-correction specification, which has permitted us to by-pass to a certain extent the criticism according to which cash flow might affect investment, simply because it accounts for investment opportunities, not properly measured by *Q*. Furthermore, in addition to analyzing how the sensitivities of investment to cash flow differ at firms facing different degrees of internal financial constraints on the one hand, and different degrees of external financial constraints, on the other, we have also focused on the effects of various combinations of internal and external financial constraints on the sensitivities, trying to identify the combinations leading to the highest sensitivities.

According to our results, which were generally robust to considering only the manufacturing sector or a broader range of industries, when the sample is split on the basis of the level of internal funds available to the firms, the relationship between investment and cash flow is U-shaped. On the other hand, the sensitivity of investment to cash flow tends to increase monotonically with the degree of external financial constraints faced by firms. These findings suggest that the different conclusions reached by FHP (1988) and KZ (1997) about whether higher sensitivities of investment to cash flow can be interpreted as evidence that firms are more financially constrained, are probably due to the different criteria used in their studies to partition their sample. Finally, combining the internal with the external financial constraints, we find that the sensitivities are the highest for those externally financially constrained firms that have a relatively high level of internal funds.

Although our paper provides a reconciliation for the contradictory findings in FHP (1988) and KZ (1999), it does not deal with the other challenges that have been addressed in the literature to the hypothesis that a significant coefficient on cash flow in an investment reduced form regression can be seen as an indication of the existence of financial constraints. Authors such as Alti (2003) and Boyle and Guthrie (2003), for instance, construct theoretical models respectively showing that unconstrained firms can plausibly exhibit the sensitivities documented in the literature, and that firms facing (by construction) identical constraints can nevertheless exhibit different sensitivities due to differences in investment flexibility. The question of whether high sensitivities of investment to cash flow can be seen as indicators of financial constraints remains therefore a controversial question, which will undoubtedly generate future research.

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Table 1: Descriptive statistics

Panel A: Manufacturing sector

	All firm-years	Firm-years such that $NEGCF_{it}$=1	Firm-years such that. $MEDCF_{it}$=1	Firm-years such that $HIGHCF_{it}$=1	Firm-years such that $SMALL_{it}$=1	Firm-years such that $MEDIUM_{it}$=1	Firm-years such that $LARGE_{it}$=1
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Real assets	388.30 (4294.0)	325.29 (1652.6)	417.26 (4173.5)	347.44 (5424.0)	11.782 (4.70)	51.533 (31.61)	983.18 (7038.2)
$I_{it} / K_{i(t-1)}$	0.168 (0.26)	0.119 (0.27)	0.145 (0.21)	0.255 (0.36)	0.179 (0.28)	0.169 (0.27)	0.162 (0.25)
Δs_{it}	0.030 (0.22)	-0.096 (0.27)	-0.004 (0.19)	0.072 (0.22)	0.009 (0.23)	-0.00003 (0.21)	0.004 (0.21)
$(k_{i(t-2)}-s_{i(t-2)})$	-1.576 (0.89)	-1.587 (0.88)	-1.330 (0.76)	-2.201 (0.88)	-1.976 (0.94)	-1.601 (0.87)	-1.376 (0.81)
$CF_{it} / K_{i(t-1)}$	0.371 (0.71)	-0.331 (0.45)	0.219 (0.13)	1.134 (1.00)	0.481 (0.89)	0.357 (0.68)	0.342 (0.66)
Number of observations	39270	5096	24599	9575	6063	18753	14454

Notes: The Table reports sample means. Standard deviations are presented in parentheses. The subscript i indexes firms, and the subscript t, time, where t=1996-2003. I represents the firm's investment; K, the replacement value of its capital stock; s, the logarithm of its sales; k, the logarithm of its capital stock; and CF, its cash flow. $NEGCF_{it}$ is a dummy variable equal to 1 if firm i has a negative cash flow to capital ratio at time t, and equal to 0, otherwise. $MEDCF_{it}$ is a dummy variable equal to 1 if firm i has a positive cash flow to capital ratio in year t, which falls below the 75th percentile of the distribution of the cash flow to capital ratios of all firms belonging to the same industry as firm i in year t. $HIGHCF_{it}$ is a dummy equal to 1 if firm i's cash flow to capital ratio is positive in year t, and above the 75th percentile of the distribution of the cash flow to capital ratios of all firms belonging to the same industry as firm i in year t, and equal to 0 otherwise. $SMALL_{it}$ is a dummy variable equal to 1 if firm i's total real assets are in the lowest quartile of the distribution of the total assets of all firms belonging to the same industry as firm i in year t, and 0, otherwise. $MEDIUM_{it}$ is a dummy variable equal to 1 if firm i's total assets are in the second and third quartiles of the distribution of the total assets of all firms belonging to the same industry as firm i in year t, and 0, otherwise. $LARGE_{it}$ is a dummy variable equal to 1 if firm i's total assets are in the highest quartile of the distribution of the total assets of all firms belonging to the same industry as firm i in year t, and 0, otherwise.

Panel B: Broader sample

	All firm-years	Firm-years such that $NEGCF_{it}$=1	Firm-years such that. $MEDCF_{it}$=1	Firm-years such that $HIGHCF_{it}$=1	Firm-years such that $SMALL_{it}$=1	Firm-years such that $MEDIUM_{it}$=1	Firm-years such that $LARGE_{it}$=1
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Real assets	323.806 (4639.1)	287.43 (4396.0)	331.81 (3912.0)	321.739 (6303.0)	8.542 (4.21)	37.453 (21.92)	880.307 (7855.6)
$I_{it} / K_{i(t-1)}$	0.194 (0.36)	0.158 (0.39)	0.158 (0.27)	0.310 (0.52)	0.207 (0.40)	0.192 (0.36)	0.190 (0.35)
Δs_{it}	0.030 (0.26)	-0.074 (0.32)	0.024 (0.22)	0.103 (0.27)	0.034 (0.26)	0.024 (0.26)	0.036 (0.25)
$(k_{i(t-2)}-s_{i(t-2)})$	-1.789 (1.34)	-1.811 (1.30)	-1.445 (1.23)	-2.714 (1.20)	-2.220 (1.16)	-1.778 (1.30)	-1.571 (1.42)
$CF_{it} / K_{i(t-1)}$	0.548 (1.43)	-0.586 (0.96)	0.261 (0.20)	1.951 (2.30)	0.688 (1.61)	0.522 (1.41)	0.508 (1.36)
Number of observations	124590	15873	79612	29105	23045	58426	43119

Notes: The Table reports sample means. Standard deviations are presented in parentheses. The subscript i indexes firms, and the subscript t, time, where t=1996-2003. I represents the firm's investment; K, the replacement value of its capital stock; s, the logarithm of its sales; k, the logarithm of its capital stock; and CF, its cash flow. $NEGCF_{it}$ is a dummy variable equal to 1 if firm i has a negative cash flow to capital ratio at time t, and equal to 0, otherwise. $MEDCF_{it}$ is a dummy variable equal to 1 if firm i has a positive cash flow to capital ratio in year t, which falls below the 75th percentile of the distribution of the cash flow to capital ratios of all firms belonging to the same industry as firm i in year t. $HIGHCF_{it}$ is a dummy equal to 1 if firm i's cash flow to capital ratio is positive in year t, and above the 75th percentile of the distribution of the cash flow to capital ratios of all firms belonging to the same industry as firm i in year t, and equal to 0 otherwise. $SMALL_{it}$ is a dummy variable equal to 1 if firm i's total real assets are in the lowest quartile of the distribution of the total assets of all firms belonging to the same industry as firm i in year t, and 0, otherwise. $MEDIUM_{it}$ is a dummy variable equal to 1 if firm i's total assets are in the second and third quartiles of the distribution of the total assets of all firms belonging to the same industry as firm i in year t, and 0, otherwise. $LARGE_{it}$ is a dummy variable equal to 1 if firm i's total assets are in the highest quartile of the distribution of the total assets of all firms belonging to the same industry as firm i in year t, and 0, otherwise.

Table 2: Is the investment curve U-shaped?

$CF_{it}/K_{i(t-1)}$ *percentiles*	Manufacturing Mean $CF_{it}/K_{i(t-1)}$ (1)	Manufacturing Mean $I_{it}/K_{i(t-1)}$ (2)	Broader sample Mean $CF_{it}/K_{i(t-1)}$ (3)	Broader sample Mean $I_{it}/K_{i(t-1)}$ (4)
<=1%	<= (-1.03)	0.23	<= (-2.02)	0.36
2%-5%	(-1.03) – (-0.24)	0.15	(-2.02) – (-0.34)	0.22
6%-10%	(-0.24) – (-0.048)	0.12	(-0.34) – (-0.005)	0.14
11%-25%	(-0.048) – 0.11	0.10	(-0.005) – 0.10	0.10
26%-50%	0.11 – 0.24	0.13	0.10 – 0.26	0.14
51%-75%	0.24 – 0.49	0.20	0.26 – 0.63	0.22
76%-90%	0.49 – 0.99	0.25	0.63- 1.52	0.31
90%-95%	0.99 – 1.53	0.33	1.52 – 2.66	0.41
95%-99%	1.53 – 3.54	0.37	2.66 – 7.29	0.49
>99%	> 3.54	0.40	>7.29	0.57

Notes: The subscript *i* indexes firms, and the subscript *t*, time, where *t*=1996-2003. *I* represents the firm's investment; *K*, the replacement value of its capital stock; and *CF*, its cash flow.

Table 3: The effects of cash flow on investment: an error-correction approach

Dependent Variable: $I_{it} / K_{i(t-1)}$	Full sample Manuf. (1)	Full sample Broader sample (2)	Excluding obs. with $CF_{it} / K_{i(t-1)}$<0 Manuf. (3)	Excluding obs. with $CF_{it} / K_{i(t-1)}$<0 Broader sample (4)
$I_{i(t-1)} / K_{i(t-2)}$	-0.093**	-0.056**	-0.131**	-0.073**
	(0.04)	(0.02)	(0.05)	(0.03)
Δs_{it}	0.357**	0.425**	0.564***	0.451**
	(0.17)	(0.18)	(0.19)	(0.21)
$\Delta s_{i(t-1)}$	0.241***	0.205***	0.279***	0.215***
	(0.06)	(0.04)	(0.07)	(0.05)
$(k_{i(t-2)}-s_{i(t-2)})$	-0.218***	-0.159***	-0.254***	-0.178***
	(0.06)	(0.04)	(0.08)	(0.05)
$CF_{it} / K_{i(t-1)}$	0.055***	0.038***	0.084***	0.043***
	(0.02)	(0.01)	(0.03)	(0.01)
m2	-0.91	-0.08	-1.37	-0.02
J (*p*-value)	0.81	0.02	0.79	0.11
Sample size	39270	124590	30788	97551

Notes: All specifications were estimated using a GMM first-difference specification. The figures reported in parentheses are asymptotic standard errors. Time dummies and time dummies interacted with industry dummies were included in all specifications. Standard errors and test statistics are asymptotically robust to heteroskedasticity. *m2* is a test for second-order serial correlation in the first-differenced residuals, asymptotically distributed as N(0,1) under the null of no serial correlation. The *J* statistic is a test of the overidentifying restrictions, distributed as chi-square under the null of instrument validity. Instruments in both columns are $(k_{i(t-2)}-s_{i(t-2)})$, $I_{i(t-2)} /K_{i(t-3)}$, $\Delta s_{i(t-2)}$, $CF_{i(t-2)} /K_{i(t-3)}$ and further lags. Time dummies and time dummies interacted with industry dummies were always included in the instrument set. Also see Notes to Table 1. * indicates significance at the 10% level. ** indicates significance at the 5% level. *** indicates significance at the 1% level.

Table 4: The effects of cash flow on investment: distinguishing firm-years on the basis of the degree of internal financial constraints that they face

Dependent Variable: $I_{it} / K_{i(t-1)}$	*CF*-interactions Manuf. (1)	*CF*-interactions Broader sample (2)	*COV*-interactions Manuf. (3)	*COV*-interactions Broader sample (4)
$I_{i(t-1)} / K_{i(t-2)}$	-0.070** (0.03)	-0.064** (0.02)	-0.105** (0.05)	-0.048 (0.03)
Δs_{it}	0.212** (0.09)	0.509*** (0.13)	0.322** (0.15)	0.422*** (0.14)
$\Delta s_{i(t-1)}$	0.222*** (0.04)	0.214*** (0.04)	0.255*** (0.07)	0.187*** (0.05)
$(k_{i(t-2)}-s_{i(t-2)})$	-0.198*** (0.05)	-0.165*** (0.04)	-0.228*** (0.07)	-0.135** (0.06)
$(CF_{it}/K_{i(t-1)})*NEGCF_{it}$	-0.152** (0.07)	-0.047* (0.027)		
$(CF_{it}/K_{i(t-1)})*MEDCF_{it}$	-0.056 (0.07)	-0.046 (0.06)		
$(CF_{it}/K_{i(t-1)})*HIGHCF_{it}$	0.065*** (0.02)	0.045*** (0.01)		
$(CF_{it}/K_{i(t-1)})*NEGCOV_{it}$			-0.195** (0.097)	-0.062** (0.03)
$(CF_{it}/K_{i(t-1)})*MEDCOV_{it}$			0.021 (0.04)	0.078** (0.03)
$(CF_{it}/K_{i(t-1)})*HIGHCOV_{it}$			0.097*** (0.04)	0.065*** (0.02)
H_0: Impact of $CF_{it}/K_{i(t-1)}$ on $I_{it} / K_{i(t-1)}$ same across firm-years with negative and medium-sized CF_{it}/COV_{it} (*p*-value)	0.41	0.99	0.05*	0.002***
H_0: Impact of $CF_{it}/K_{i(t-1)}$ on $I_{it} / K_{i(t-1)}$ same across firm-years with negative and large CF_{it}/COV_{it} (*p*-value)	0.0085***	0.005***	0.007***	0.0005***
H_0: Impact of $CF_{it}/K_{i(t-1)}$ on $I_{it} / K_{i(t-1)}$ same across firm-years with medium-sized and large CF_{it}/COV_{it} (*p*-value)	0.06*	0.11	0.04**	0.63
m2	-0.89	-0.28	-0.37	-0.85
J (*p*-value)	0.522	0.132	0.30	0.05
Sample size	39270	124590	30087	91886

Notes: $NEGCOV_{it}$ is a dummy variable equal to 1 if firm *i* has a negative coverage ratio at time *t*, and equal to 0, otherwise. $MEDCOV_{it}$ is a dummy equal to 1 if firm *i* has a positive coverage ratio in year *t*, which falls below the 75th percentile of the distribution of the coverage ratios of all firms belonging to the same industry as firm *i* in year *t*. $HIGHCOV_{it}$ is a dummy equal to 1 if firm *i*'s coverage ratio is positive in year *t*, and above the 75th percentile of the distribution of the coverage ratios of all firms belonging to the same industry as firm *i* in year *t*, and equal to 0 otherwise. All specifications were estimated using a GMM first-difference specification. The figures reported in parentheses are asymptotic standard errors. Time dummies and time dummies interacted with industry dummies were included in all specifications. Standard errors and test statistics are asymptotically robust to heteroskedasticity. Instruments in columns (1) and (2) are $(k_{i(t-2)}-s_{i(t-2)})$, $I_{i(t-2)}/K_{i(t-3)}$, $\Delta s_{i(t-2)}$, $CF_{i(t-2)}/K_{i(t-3)} *(NEGFC_{i(t-2)})$, $CF_{i(t-2)}/K_{i(t-3)} *(MEDCF_{i(t-2)})$, and $CF_{i(t-2)}/K_{i(t-3)} *(HIGHCF_{i(t-2)})$ and further lags. Instruments in columns (3) and (4) are $(k_{i(t-2)}-s_{i(t-2)})$, $I_{i(t-2)}/K_{i(t-3)}$, $\Delta s_{i(t-2)}$, $CF_{i(t-2)}/K_{i(t-3)} *(NEGCOV_{i(t-2)})$, $CF_{i(t-2)}/K_{i(t-3)} *(MEDCOV_{i(t-2)})$, and $CF_{i(t-2)}/K_{i(t-3)} *(HIGHCOV_{i(t-2)})$ and further lags. Time dummies and time dummies interacted with industry dummies were always included in the instrument set. *m2* is a test for second-order serial correlation in the first-differenced residuals, asymptotically distributed as N(0,1) under the null of no serial correlation. The *J* statistic is a test of the overidentifying restrictions, distributed as chi-square under the null of instrument validity. The numbers in the rows testing whether the impact of $CF_{it}/K_{i(t-1)}$ on $I_{it} / K_{i(t-1)}$ is the same across various categories of firm-years are the *p*-values associated with χ^2 tests for general restrictions. Also see Notes to Table 1. * indicates significance at the 10% level. ** indicates significance at the 5% level. *** indicates significance at the 1% level.

Table 5: The effects of cash flow on investment: distinguishing firm-years on the basis of the degree of external financial constraints that they face

Dependent Variable: $I_{it} / K_{i(t-1)}$	Size-interactions	Size-interactions	Age-interactions	Age-interactions
	Manuf.	Broader sample	Manuf.	Broader sample
	(1)	(2)	(3)	(4)
$I_{i(t-1)} / K_{i(t-2)}$	-0.133***	-0.074***	-0.134***	-0.062**
	(0.05)	(0.02)	(0.04)	(0.02)
Δs_{it}	0.561***	0.509***	0.506***	0.388**
	(0.19)	(0.16)	(0.143)	(0.16)
$\Delta s_{i(t-1)}$	0.285***	0.231***	0.291***	0.218***
	(0.06)	(0.04)	(0.06)	(0.04)
$(k_{i(t-2)}-s_{i(t-2)})$	-0.261***	-0.188***	-0.268***	-0.175***
	(0.06)	(0.04)	(0.06)	(0.04)
$(CF_{it} /K_{i(t-1)})*SMALL_{it}$	0.105***	0.076***		
	(0.03)	(0.02)		
$(CF_{it} /K_{i(t-1)})* MEDIUM_{it}$	0.052***	0.031***		
	(0.02)	(0.01)		
$(CF_{it} /K_{i(t-1)})* LARGE_{it}$	0.005	0.018		
	(0.03)	(0.01)		
$(CF_{it} /K_{i(t-1)})*YOUNG_{it}$			0.065**	0.048***
			(0.03)	(0.01)
$(CF_{it} /K_{i(t-1)})*MIDDLEAGED_{it}$			0.053**	0.040***
			(0.02)	(0.01)
$(CF_{it} /K_{i(t-1)})*OLD_{it}$			-0.016	-0.001
			(0.03)	(0.01)
H_0: Impact of $CF_{it} /K_{i(t-1)}$ on $I_{it} / K_{i(t-1)}$ same across small/young and medium-sized/middle-aged firm-years (*p*-value)	0.10	0.01***	0.70	0.49
H_0: Impact of $CF_{it} /K_{i(t-1)}$ on $I_{it} / K_{i(t-1)}$ same across small/young and large/old firm-years (*p*-value)	0.013**	0.005***	0.04**	0.0009***
H_0: Impact of $CF_{it} /K_{i(t-1)}$ on $I_{it} / K_{i(t-1)}$ same across firm-years with medium-sized/middle-aged and large/old firm-years (*p*-value)	0.08*	0.34	0.03**	0.003***
m2	-1.17	-0.20	-0.93	0.019
J (*p*-value)	0.88	0.03	0.76	0.05
Sample size	39270	124581	39270	124581

Notes: $YOUNG_{it}$ is a dummy equal to 1 if firm *i*'s age is in the lowest quartile of the distribution of the ages of all firms belonging to the same industry as firm *i* in year *t*, and 0, otherwise. $MIDDLEAGED_{it}$ is a dummy equal to 1 if firm *i*'s age is in the second and third quartiles of the distribution of the ages of all firms belonging to the same industry as firm *i* in year *t*, and 0, otherwise. OLD_{it} is a variable equal to 1 if firm *i*'s age is in the highest quartile of the distribution of the ages of all firms belonging to the same industry as firm *i* in year *t*, and 0, otherwise. All specifications were estimated using a GMM first-difference specification. The figures reported in parentheses are asymptotic standard errors. Time dummies and time dummies interacted with industry dummies were included in all specifications. Standard errors and test statistics are asymptotically robust to heteroskedasticity. Instruments in columns (1) and (2) are $(k_{i(t-2)}-s_{i(t-2)})$, $I_{i(t-2)} /K_{i(t-3)}$, $\Delta s_{i(t-2)}$, $CF_{i(t-2)}/K_{i(t-3)} *(SMALL_{i(t-2)})$, $CF_{i(t-2)}/K_{i(t-3)} *(MEDIUM_{i(t-2)})$, and $CF_{i(t-2)}/K_{i(t-3)} *(LARGE_{i(t-2)})$ and further lags. Instruments in columns (3) and (4) are $(k_{i(t-2)}-s_{i(t-2)})$, $I_{i(t-2)} /K_{i(t-3)}$, $\Delta s_{i(t-2)}$, $CF_{i(t-2)}/K_{i(t-3)} *(YOUNG_{i(t-2)})$, $CF_{i(t-2)}/K_{i(t-3)} *(MIDDLEAGED_{i(t-2)})$, and $CF_{i(t-2)}/K_{i(t-3)} *(OLD_{i(t-2)})$ and further lags. Time dummies and time dummies interacted with industry dummies were always included in the instrument set. *m2* is a test for second-order serial correlation in the first-differenced residuals, asymptotically distributed as N(0,1) under the null of no serial correlation. The *J* statistic is a test of the overidentifying restrictions, distributed as chi-square under the null of instrument validity. The numbers in the rows testing whether the impact of $CF_{it} /K_{i(t-1)}$ on $I_{it} / K_{i(t-1)}$ is the same across various categories of firm-years are the *p*-values associated with χ^2 tests for general restrictions. Also see Notes to Table 1. * indicates significance at the 10% level. ** indicates significance at the 5% level. *** indicates significance at the 1% level.

Table 6: The effects of cash flow on investment: distinguishing firm-years on the basis of combinations of different degrees of internal and external financial constraints

Dependent Variable: $I_{it} / K_{i(t-1)}$	Cash flow and size interactions Manuf. (1)	Cash flow and size interactions Broader sample (2)	Coverage ratio and age interactions Manuf. (3)	Coverage ratio and age interactions Broader sample (4)
$I_{i(t-1)} / K_{i(t-2)}$	-0.100**	-0.093***	-0.076	-0.095***
	(0.05)	(0.03)	(0.06)	(0.03)
Δs_{it}	0.323**	0.460***	0.157	0.505***
	(0.15)	(0.14)	(0.19)	(0.14)
$\Delta s_{i(t-1)}$	0.247***	0.262***	0.220**	0.257***
	(0.06)	(0.04)	(0.08)	(0.06)
$(k_{i(t-2)}-s_{i(t-2)})$	-0.239***	-0.232***	-0.201**	-0.225***
	(0.07)	(0.05)	(0.08)	(0.06)
$(CF_{it}/K_{i(t-1)})*(NEGCF_{it}/NEGCOV_{it})*$ $(SMALL_{it}/YOUNG_{it})$	-0.194	-0.077	-0.106	0.014
	(0.18)	(0.09)	(0.16)	(0.11)
$(CF_{it}/K_{i(t-1)})*(NEGCF_{it}/NEGCOV_{it})*$ $(MEDIUM_{it}/MIDDLEAGED_{it})$	-0.167	-0.090**	-0.177	-0.04
	(0.13)	(0.03)	(0.13)	(0.04)
$(CF_{it}/K_{i(t-1)})*(NEGCF_{it}/NEGCOV_{it})*$ $(LARGE_{it}/OLD_{it})$	-0.079	0.049	-0.050	-0.132
	(0.14)	(0.06)	(0.20)	(0.10)
$(CF_{it}/K_{i(t-1)})*(MEDCF_{it}/MEDCOV_{it})*$ $(SMALL_{it}/YOUNG_{it})$	0.271	0.196	0.043	0.048
	(0.21)	(0.17)	(0.07)	(0.04)
$(CF_{it}/K_{i(t-1)})*(MEDCF_{it}/MEDCOV_{it})*$ $(MEDIUM_{it}/MIDDLEAGED_{it})$	-0.024	-0.091	0.018	0.071**
	(0.12)	(0.07)	(0.05)	(0.03)
$(CF_{it}/K_{i(t-1)})*(MEDCF_{it}/MEDCOV_{it})*$ $(LARGE_{it}/OLD_{it})$	0.089	-0.102	-0.014	0.018
	(0.10)	(0.07)	(0.13)	(0.05)
$(CF_{it}/K_{i(t-1)})*(HIGHCF_{it}/HIGHCOV_{it})*$ $(SMALL_{it}/YOUNG_{it})$	0.143***	0.074***	0.158**	0.088***
	(0.03)	(0.02)	(0.06)	(0.03)
$(CF_{it}/K_{i(t-1)})*(HIGHCF_{it}/HIGHCOV_{it})*$ $(MEDIUM_{it}/MIDDLEAGED_{it})$	0.091***	0.040***	0.095**	0.058**
	(0.03)	(0.01)	(0.04)	(0.02)
$(CF_{it}/K_{i(t-1)})*(HIGHCF_{it}/HIGHCOV_{it})*$ $(LARGE_{it}/OLD_{it})$	0.059	0.019	-0.010	-0.0006
	(0.04)	(0.016)	(0.06)	(0.02)
m2	-0.893	0.542	-0.123	0.090
J (*p*-value)	0.967	0.542	0.609	0.418
Sample size	39270	124590	30083	91877

Notes: All specifications were estimated using a GMM first-difference specification. The figures reported in parentheses are asymptotic standard errors. Time dummies and time dummies interacted with industry dummies were included in all specifications. Standard errors and test statistics are asymptotically robust to heteroskedasticity. Instruments in all columns are $(k_{i(t-2)}-s_{i(t-2)})$, $I_{i(t-2)} /K_{i(t-3)}$, $\Delta s_{i(t-2)}$ and further lags, together with the relevant multiple interaction terms lagged twice or more. Time dummies and time dummies interacted with industry dummies were always included in the instrument set. *m2* is a test for second-order serial correlation in the first-differenced residuals, asymptotically distributed as N(0,1) under the null of no serial correlation. The *J* statistic is a test of the overidentifying restrictions, distributed as chi-square under the null of instrument validity. Also see Notes to Tables 1, 4, and 5. * indicates significance at the 10% level. ** indicates significance at the 5% level. *** indicates significance at the 1% level.